



## Original Research—CME

# Men With Late Effects of Polio Decline More Than Women in Lower Limb Muscle Strength: A 4-Year Longitudinal Study

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## Abstract

**Background:** In persons with prior paralytic poliomyelitis, progressive muscle weakness can occur after a stable period of at least 15 years. Knowledge is limited about which factors influence changes in lower limb muscle strength in these persons.

**Objective:** To assess changes in lower limb muscle strength annually over 4 years in persons with late effects of polio and to identify prognostic factors for changes in muscle strength.

**Design:** A prospective, longitudinal study.

**Setting:** University hospital outpatient program.

**Participants:** Fifty-two ambulant persons (mean age  $\pm$  standard deviation:  $64 \pm 6$  years) with verified late effects of polio.

**Methods:** Mixed linear models were used to analyze changes in muscle strength and to identify determinants among the following covariates: gender, age, age at acute polio infection, time with late effects of polio, body mass index, and estimated baseline muscle weakness.

**Main Outcome Measurements:** Knee extensor and flexor and ankle dorsiflexor muscle strength were measured annually with a Biodex dynamometer.

**Results:** The men ( $n = 28$ ) had significant linear change over time for all knee muscle strength measurements, from  $-1.4\%$  ( $P < .05$ ) per year for isokinetic knee flexion in the less-affected lower limb to  $-4.2\%$  ( $P < .001$ ) for isokinetic knee extension in the more-affected lower limb, and for 2 ankle dorsiflexor muscle strength measurements ( $-3.3\%$ - $1.4\%$  per year [ $P < .05$ ]). The women ( $n = 24$ ) had a significant linear change over time only for ankle dorsiflexor measurements ( $4.0\%$ - $5.5\%$  per year [ $P < .01$ ]). Gender was the strongest factor that predicted a change in muscle strength over time.

**Conclusions:** Over 4 years, men had a greater decline in muscle strength than did women, but the rate of decline did not accelerate. This finding indicates that gender could be a contributing factor to the progressive decline in muscle strength in persons with late effects of polio.

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## Introduction

In persons with a history of an acute paralytic poliomyelitis infection, new symptoms are experienced by 28%-64% after a stable period of at least 15 years [1,2]. These new symptoms are referred to as "late effects of polio" or "postpolio syndrome" [3] and often include muscle weakness, general fatigue, muscle pain, and/or joint pain [1,4-6]. These symptoms can lead to reduced mobility in daily activities such as walking, standing, and climbing stairs [7-9]. Progressive decline in muscle strength is an underlying cause of the reduced mobility

[10,11] and is likely to increase when these persons acquire additional disabilities [12,13].

In healthy men and women (aged 50-70 years), the predicted decline in knee and ankle dorsiflexor muscle strength is 1%-2% per year [14]. A decline in muscle strength also occurs over time in persons with late effects of polio, but the rapidity of this decline is unclear. In a review from 2005 (including 17 articles with sample sizes from 12-103 participants) most studies showed a slow rate of decline in muscle strength over time [15], with approximately 7% over 4 years and 15% over 8 years [16-19]. Thereafter, few

studies have assessed the decline in lower limb muscle strength in persons with late effects of polio [20-23]. The decline in muscle strength in those studies is reported to be between 1% and 3% [20,22,23], except for one study that reported a larger and more progressive decline (5%-8% per year) [21].

Very few studies have assessed prognostic factors for the decline in muscle strength in persons with late effects of polio. One study showed that men declined more rapidly in isokinetic knee extensor strength than did women [11]. Willén et al [23] found that the decline in muscle strength over 4 years was higher in persons who were stronger at the baseline assessment. In a recent study, Bickerstaffe et al [20] showed that persons with higher isometric maximal voluntary contraction (MVC) at baseline had a greater decline in strength over 10 years.

Even though previous studies have evaluated the decline in muscle strength over time in persons with late effects of polio, they differ with regard to study design and the statistical methods used. To analyze longitudinal data in order to identify potential determinants, the mixed-random and fixed effect regression models (mixed linear models; MLM) are recommended [24-26]. To our knowledge, no study has used the MLM model to assess changes in muscle strength over time in persons with late effects of polio.

The main aim of this study was to assess changes in strength in the knee extensor and flexor muscles and ankle dorsiflexor muscles annually over 4 years in persons with late effects of polio. The second aim was to identify determinants of changes in muscle strength, such as gender, age, age at acute polio infection, length of time with new symptoms, body mass index (BMI), and estimated baseline weakness.

## Methods

### Participants

Fifty-two community-dwelling ambulant persons were recruited from a postpolio rehabilitation clinic at a university hospital in the south of Sweden. Inclusion criteria were (1) 50-75 years of age; (2) a confirmed history of acute poliomyelitis affecting the lower limbs, with new weakness after a period of functional stability of at least 15 years; and (3) ability to walk at least 300 m with or without an assistive and/or orthotic device. Exclusion criteria were (1) using a wheelchair as the main mode of transportation and (2) ongoing major depression, systemic disease, or any other disease that could affect muscle strength. The treating physician selected participants who met the inclusion and exclusion criteria and were mildly to moderately affected in their lower limbs. These persons were invited consecutively to participate in the study in connection with their regular follow-up visits to the

clinic. We aimed for at least 50 participants to obtain a reasonably large sample that could be assessed annually over the 4-year period. Inclusion continued for 18 months (2007 to 2009) until 52 persons had agreed to participate.

For all 52 participants, an electromyogram had been recorded in the lower limbs (vastus lateralis and tibialis anterior muscles) as part of the initial routine clinical examination and verification of prior polio, and there were no other diseases that could explain their new symptoms. According to the National Rehabilitation Hospital (NRH) Post-Polio Limb Classification [27], all participants had postpolio NRH class II to V (indicating clinically stable or unstable polio) in at least one of their knee or ankle dorsiflexor muscles. According to each person's own perception of his or her muscle weakness, one lower limb was defined as the "more-affected limb" and the other lower limb that was less affected or not affected was defined as the "less-affected limb."

Prior to inclusion in the study, information about the purpose of the study was provided, and each individual gave his or her written informed consent to participate. The study followed the principles of the Helsinki declaration.

### Muscle Strength Measurements

Isokinetic concentric knee extension, knee flexion, and ankle dorsiflexion muscle strength and isometric knee extension and ankle dorsiflexion muscle strength were measured with a Biodex Multi-Joint System 3 PRO dynamometer (Biodex Medical Systems, Shirley, NY) using a standard protocol developed in our research group [28,29]. These studies have shown that lower limb muscle strength can be reliably measured in persons with late effects of polio (for knee extensors and flexors, intraclass correlation coefficients [ $ICC_{2,1}$ ] ranging from 0.85-0.99 and standard error of measurement [SEM] from 10.2-13.9 Newton meter [Nm], and for ankle dorsiflexors,  $ICC_{2,1}$  ranging from 0.85-0.99 and SEM from 2.5-3.7 Nm).

Before each strength measurement, the range of motion was set and the Biodex software applied the gravity correction. For the knee muscle strength measurements, the participants were seated in the adjustable chair of the dynamometer without shoes or an orthotic device and were stabilized with straps across the shoulders, waist, and thigh. After a structured warm-up the participants performed 3 maximal isokinetic extensor and flexor contractions at 60°/s, and the highest peak torques were recorded (in Nm). After a 2-minute rest, the participants performed 2 maximal isometric knee extensor muscle contractions with a knee flexion angle at 90°, and the highest MVC was recorded (in Nm).

For the ankle dorsiflexor strength measurements, the participants were seated in the adjustable chair of the

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